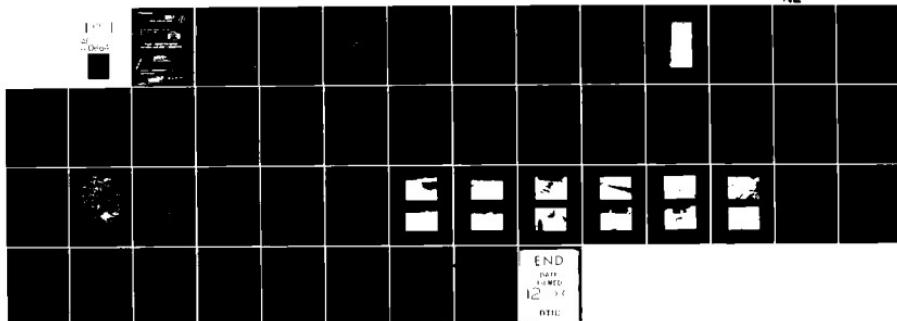


AD-A106 641 BLACK AND VEATCH KANSAS CITY MO F/G 13/13
NATIONAL DAM SAFETY PROGRAM, CITY OF CAMERON RESERVOIR NUMBER 1--ETC(U)
JUL 79 P R ZAMAN, E R BURTON, H L CALLAHAN DACW43-79-C-0040
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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
		AD-A106 641
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19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Dam Safety, Lake, Dam Inspection, Private Dams	20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.	

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GRAND-CHARITON BASIN

CITY OF CAMERON RESERVOIR NO. 1 DAM
DEKALB COUNTY, MISSOURI
MO 10042

PHASE 1 INSPECTION REPORT NATIONAL DAM SAFETY INSPECTION

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United States Army
Corps of Engineers
*...Serving the Army
...Serving the Nation*

St. Louis District

PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
FOR: STATE OF MISSOURI

JULY 1979



DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 NORTH 12TH STREET
ST. LOUIS, MISSOURI 63101

IN REPLY REFER TO

SUBJECT: Cameron Reservoir No. 1 Dam Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Cameron Reservoir No. 1 Dam:

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, non-emergency by the St. Louis District as a result of the application of the following criteria:

1. Spillway will not pass 50 percent of the Probable Maximum Flood.
2. Overtopping could result in failure of the dam.
3. Dam failure significantly increases the hazard to loss of life downstream.

SUBMITTED BY:

SIGNED

20 DEC 1979

Date

Chief, Engineering Division

APPROVED BY:

SIGNED

20 DEC 1979

Date

Colonel, CE, District Engineer

CITY OF CAMERON RESERVOIR NO. 1 DAM
DE KALB COUNTY, MISSOURI

MISSOURI INVENTORY NO. 10042

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

PREPARED BY:

BLACK & VEATCH
CONSULTING ENGINEERS
KANSAS CITY, MISSOURI

UNDER DIRECTION OF
ST. LOUIS DISTRICT CORPS OF ENGINEERS
FOR
GOVERNOR OF MISSOURI

JULY 1979

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam	City of Cameron Reservoir No. 1 Dam
State Located	Missouri
County Located	De Kalb County
Stream	Tributary to Grindstone Creek
Date of Inspection	3 July 1979

City of Cameron Reservoir No. 1 Dam, hereafter referred to as Cameron Reservoir No. 1 Dam, was inspected by a team of engineers from Black & Veatch, Consulting Engineers for the St. Louis District, Corps of Engineers. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers and developed with the help of several Federal and state agencies, professional engineering organizations, and private engineers. Based on these guidelines, this dam is classified as a small size dam with a high downstream hazard potential. According to the St. Louis District, Corps of Engineers, the estimated damage zone extends approximately four miles downstream of the dam. Within the damage zone are four homes, Cameron Reservoir, and two county roads.

Our inspection and evaluation indicates the spillway and sluice gate acting together do not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. The spillway and sluice gate will not pass the probable maximum flood without overtopping but will pass 30 percent of the probable maximum flood, which is greater than the 100-year flood. The spillway design flood recommended by the guidelines is 50 to 100 percent of the probable maximum flood. The probable maximum flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. Considering the head differential between Cameron Reservoir No. 1 and the Cameron Reservoir immediately downstream along with the fact that Cameron Reservoir serves as the water supply for the City of Cameron, Missouri, the probable maximum flood is the appropriate spillway design flood.

Deficiencies visually observed by the inspection team were cracks in the embankment at the upstream slope/crest interface, seepage at the

right abutment, presence of heavy vegetation and small trees on the upstream face, erosion of the upstream face and behind the left spillway retaining wall, inadequately graded road on the crest, presence of animal burrows, deterioration of concrete at the downstream toe of the spillway, and tree growth obstructing spillway discharges. Seepage and stability analyses required by the guidelines were not available.

There were no deficiencies or conditions existing at the time of the inspection which raised questions concerning the safety of this structure. Future corrective action and regular maintenance will be required to correct or control the described deficiencies. In addition, detailed seepage and stability analyses of the existing dam, as required by the guidelines, should be performed. A detailed report discussing each of these deficiencies is attached.

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Illinois 62-29261

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Harry L. Callahan
Harry L. Callahan, Partner
Black & Veatch

OVERVIEW OF LAKE AND DAM



PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
CAMERON RESERVOIR NO. 1 DAM

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APPENDIX

Appendix A - Hydrologic Computations

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority. The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the District Engineer of the St. Louis District, Corps of Engineers, directed that a safety inspection of the Cameron Reservoir No. 1 Dam be made.

b. Purpose of Inspection. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

c. Evaluation Criteria. Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, in "Recommended Guidelines for Safety Inspection of Dams". These guidelines were developed with the help of several Federal agencies and many State agencies, professional engineering organizations, and private engineers.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances.

(1) The Cameron Reservoir No. 1 Dam is an earth structure located in a tributary valley to Grindstone Creek in southeastern De Kalb County, Missouri (Plate 1). The upstream slope is protected primarily by heavy vegetation, small trees, and sparsely placed large rock. Grass and weed cover protects the downstream slope. A gravel road traverses the embankment crest. What appears to be a foundation/anchor for a dock has been abandoned and consists of a concrete terrace from the embankment crest to water's edge.

(2) A concrete control sill 76 feet in length and a 2.0 by 2.0 feet sluice gate are constructed at the right abutment and serve as the spillway and gated outlet, respectively. Discharge from the sill/gate proceeds down the spillway discharge channel which is lined with broken rock and concrete. Flow then drops over a shale wall beneath the roadway approximately 70 feet downstream of the spillway.

(3) A water supply pumping station which draws water from Cameron Reservoir No. 2 is located on the downstream slope near the spillway.

(4) Pertinent physical data are given in paragraph 1.3.

b. Location. The dam is located in southeastern De Kalb County, Missouri, as indicated on Plate 1. The lake formed by the dam is located on the United States Geological Survey 15 minute series quadrangle map for Maysville, Missouri in Section 10 of T57N, R30W.

c. Size Classification. Criteria for determining the size classification of dams and impoundments are presented in the guidelines referenced in paragraph 1.1c above. Based on these criteria, the dam and impoundment are in the small size category.

d. Hazard Classification. The hazard classification assigned by the Corps of Engineers for this dam is as follows: The Cameron Reservoir No. 1 Dam has a high hazard potential, meaning that the dam is located where failure may cause loss of life, and serious damage to homes, agricultural, industrial and commercial facilities, and to important public utilities, main highways, or railroads. For the Cameron Reservoir No. 1 Dam the estimated damage zone extends approximately four miles downstream of the dam. Within the damage zone are four homes, Cameron Reservoir, and two county roads.

e. Ownership. The dam is owned by the City of Cameron, Missouri, 205 N. Main, Cameron, Missouri 64429.

f. Purpose of Dam. The dam forms a 21-acre recreational lake.

g. Design and Construction History. Information from the design file for Cameron Reservoir No. 2 provided by Black & Veatch, Consulting Engineers, Kansas City, Missouri indicated that Cameron Reservoir No. 1 Dam was constructed in 1904. The height of the dam was increased by 5.0 feet to its present crest elevation and the spillway was added at the right abutment in 1925.

h. Normal Operating Procedure. Normal rainfall, runoff, transpiration, evaporation and the capacity of the spillways all combine to maintain a relatively stable water surface elevation.

1.3 PERTINENT DATA

a. Drainage Area - 1,174 acres.

b. Discharge at Damsite.

(1) Discharge at the damsite is presently through a 2.0 by 2.0 feet sluice gate and concrete control sill at the right abutment.

- (2) Estimated experienced maximum flood at damsite - Unknown.
- (3) Estimated spillway capacity at maximum pool elevation
4,600 cfs (Probable Maximum Flood Pool El.948.5).

- c. Elevation (Feet Above M.S.L.).

- (1) Top of dam - 945.7 + (see Plate 3)
- (2) Sluice gate invert - 937.0
- (3) Spillway crest - 941.7
- (4) Streambed at toe of dam - 910.0 + (Cameron Reservoir
Normal Pool Elevation)
- (5) Maximum tailwater - Unknown.

- d. Reservoir.

- (1) Length of maximum pool - 3,500 feet +
- (2) Length of normal pool - 2,000 feet +

- e. Storage (Acre-feet).

- (1) Top of dam - 630
- (2) Spillway crest - 364
- (3) Sluice gate invert - 151
- (4) Design surcharge - Not available.

- f. Reservoir Surface (Acres).

- (1) Top of dam - 73
- (2) Spillway crest - 63
- (3) Sluice gate invert - 21

- g. Dam.

- (1) Type - Earth embankment

(2) Length - 549 feet

(3) Height - 36 feet ±

(4) Top width - 25 feet ±

(5) Side slopes - A section taken near Station 4+50 of the embankment had an upstream face slope of 1.0 V on 1.7 H and a downstream face slope which varies from 1.0 V on 2.8 H to 1.0 V on 3.4 H.

(6) Zoning - Unknown.

(7) Impervious core - Unknown.

(8) Cutoff - Unknown.

(9) Grout curtain - Unknown.

(10) Internal drainage system - None.

h. Diversion and Regulating Tunnel - None.

i. Spillway.

(1) Type - Concrete broad-crested weir.

(2) Length of weir - 76 feet.

(3) Crest elevation - 941.7 feet m.s.l.

(4) Gates - 2.0 feet by 2.0 feet sluice gate (Inv. El.937.0)

(5) Upstream channel - Not applicable.

(6) Downstream channel - The spillway and sluice gate discharge to a channel at the right abutment. The channel consists primarily of large blocks of concrete and rock on shale. Flow drops down a shale wall beneath the roadway approximately 70 feet downstream of the spillway to another channel lined with broken rock and concrete, then to Cameron Reservoir.

j. Regulating Outlets - None.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

No design data were available.

2.2 CONSTRUCTION

Construction records were unavailable; however, information contained in the design data for Cameron Reservoir No. 2, from the files of Black & Veatch, Consulting Engineers, Kansas City, Missouri indicated the dam was originally constructed in 1904.

2.3 OPERATION

Procedural criteria for operation of this dam were not available. Documentation of past experiences of a serious nature were unavailable.

2.4 GEOLOGY

The dam is located in a valley formed in shales and limestones of the Bonner Springs formation, Pennsylvanian System. These are overlain by the Gosport Variant of the Gosport Series and the Zook silty clay loam varying from 5 to 10 feet. The foundations and abutments of the dam are thought to be shale and limestone overlain by silty clay. The silty clays consist of loess over glacial till. Limestone/siltstone and shale are exposed in the downstream channel below the spillway. The bedding is horizontal and thin with closed bedding planes and a few widely spaced, vertical joints in the limestone only.

2.5 EVALUATION

a. Availability. No engineering data were available.

b. Adequacy. No engineering data were available upon which to make a detailed assessment of the design, construction, and operation. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions and made a matter of record.

c. Validity. The validity of the design, construction, and operation could not be determined due to the lack of engineering data.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. A visual inspection of Cameron Reservoir No. 1 Dam was made on 3 July 1979. The inspection team included professional engineers with experience in dam design and construction, hydrology, hydraulic engineering, and geotechnical engineering. Specific observations are discussed below. No observations were made of the condition of the upstream face of the dam below the pool elevation at the time of the inspection.

b. Dam. The inspection team observed the following items at the dam. Longitudinal cracks of 0.33 to 1.0 inches in width were observed adjacent to the crest roadway at the top of the upstream slope. The affected area was approximately 30 feet along the upstream face near station 4+00. The cracks were of undetermined depth and had minimal elevation differential between the sides. Evidence of seepage at the right abutment consisted of unusually heavy and lush growth of vegetation including cattails. No toe drains or relief wells were observed. Approximately 60 percent of the upstream slope was unobservable due to heavy vegetation. Those sections of the upstream face which were observed were characterized by small trees, brush, riprap, and localized large pieces of rock. The upper half of the downstream slope was grass covered with the lower portion primarily weeds and sparse grass patches. Erosion was evident on the upstream slope and behind the left spillway retaining wall. The roadway on the embankment crest is poorly graded and does not allow for proper drainage of runoff. Several animal burrows were observed on the embankment. There was no evidence of overtopping. The near-surface material in the embankment is silty clay as identified visually from shallow hand-auger samples. There was no evidence of any settlement or of sinkholes.

c. Appurtenant Structures. The inspection team observed the following items pertaining to appurtenant structures. The spillway consists of a concrete control sill with a sluice gate. The control sill is in good condition except for exposed reinforcing steel at the downstream toe of the sill. The sluice gate was inoperable and remained in the open position. The spillway floor is primarily shale covered with broken rock and concrete. Erosion of embankment material was observed behind the left spillway retaining wall. A stand of trees upstream of the control sill obstructs flow over the sill. An abandoned foundation/anchor, apparently used for a dock, was located on the upstream face of the dam. One 4-inch plastic pipe and one 2-inch plastic pipe were observed on the embankment on the dock anchor. The inlet and outlet of the 2-inch pipe could not be located. The 4-inch pipe was open-ended at each side near the top of the dam.

d. Reservoir Area. No slides or excessive erosion due to wave action were observed along the shore of the reservoir.

e. Downstream Channel. Discharge from the spillway and sluice gate flows to a channel lined with broken rock and concrete over shale. Flow proceeds over a roadway which is constructed as a low water concrete crossing approximately 70 feet downstream of the spillway and then falls over a shale ledge to another channel below. The lower channel flows into Cameron Reservoir and is characterized by broken rock and concrete.

3.2 EVALUATION

The inspection team observed that the embankment has minor stability problems that are unlikely to lead to failure. In reference to paragraphs 3.1b and 3.1c, it is unlikely that these items will become problems in the foreseeable future as the dam and appurtenances were observed in generally good condition. Exceptions to the previous statement are the erosion behind the left spillway retaining wall and the erosion and cracking on the upstream face which may or may not become problems in the future.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

The pool is primarily controlled by rainfall, runoff, evaporation, transpiration, and capacity of the uncontrolled spillway and sluice gate.

4.2 MAINTENANCE OF DAM

Maintenance of the embankment and appurtenances is the responsibility of the City of Cameron. Infrequent maintenance has been performed as evident in the visual inspection. The inspection team is unaware of any maintenance program.

4.3 MAINTENANCE OF OPERATING FACILITIES

The sluice gate operator was inoperable at the time of inspection and the gate was open.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

The inspection team is not aware of any existing warning system for this dam.

4.5 EVALUATION

The height of vegetal cover, presence of trees, and poor condition of the road on the embankment crest are indicative that more frequent maintenance of the dam and appurtenances is in order. The existing condition of upstream and downstream slope protection is inadequate. Periodic inspection and maintenance of these items should be initiated under the guidance of an experienced engineer.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. Design data pertaining to hydrology and hydraulics were unavailable.

b. Experience Data. The drainage area and lake surface area are developed from USGS Maysville, Plattsburg, Winston, and Polo, Missouri Quadrangle Maps. The spillway and dam layouts are from surveys made during the inspection.

c. Visual Observations.

(1) The spillway is located at the right abutment and is in generally good condition. The training and retaining walls of the spillway are in good condition with the exception of erosion behind the left spillway retaining wall.

(2) The spillway discharge channel is excavated in shale and continues until it intersects with the roadway above the shale wall. The roadway was constructed as a low-water concrete crossing. Flow then drops to a broken rock and concrete channel before it reaches Cameron Reservoir. Discharges over the spillway should not be affected by backwater effects in the discharge channel.

(3) The tailwater elevation at the time of inspection was El.909.4. The maximum tailwater elevation would be approximately El.921.9 under probable maximum storm conditions.

d. Overtopping Potential. The spillway will not pass the probable maximum flood without overtopping the dam. The probable maximum flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The spillway and gate will pass 30 percent of the probable maximum flood and the 100-year flood without overtopping the dam. The distribution for the 100-year rainfall was provided by the St. Louis District, Corps of Engineers. According to the recommended guidelines from the Department of the Army, Office of the Chief of Engineers, a high hazard dam of small size should pass 50 to 100 percent of the probable maximum flood. Considering the head differential between Cameron Reservoir No. 1 and Cameron Reservoir along with the fact that Cameron Reservoir serves as the water supply for the City of Cameron, Missouri, the probable maximum flood is the appropriate spillway design flood. The portion of the estimated peak discharge of the probable maximum flood overtopping the dam would be 3,100 cfs of the total discharge from the reservoir of 7,700 cfs. The estimated duration of overtopping is 5.5 hours with a maximum height of 2.8 feet. The

portion of the estimated peak discharge of 50 percent of the probable maximum flood overtopping the dam would be 300 of the total discharge from the reservoir of 3,300 cfs. The estimated duration of overtopping is 2.8 hours with a maximum height of 1.1 feet. Although evidence of overtopping of the embankment was not visible, soils typical of the embankment surfaces tend to erode. Should the embankment be subjected to prolonged overtopping it is believed that the subsequent erosion could lead to failure.

According to the St. Louis District, Corps of Engineers, the estimated damage zone extends approximately four miles downstream of the dam. Within the damage zone are four homes, Cameron Reservoir, and two county roads.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. Visual observations of conditions which affect the structural stability of this dam are discussed in Section 3, paragraph 3.1b.

b. Design and Construction Data. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available which is considered a deficiency.

c. Operating Records. No operational records were available.

d. Post Construction Changes. According to the design file mentioned in paragraph 2.2, the dam's height was increased by 5.0 feet to its present crest elevation and the spillway added at the right abutment in 1925.

e. Seismic Stability. The dam is located in Seismic Zone 1 which is a zone of minor seismic risk. A properly designed and constructed earth dam using sound engineering principles and conservatism should pose no serious stability problems during earthquakes in this zone.

Adequate descriptions of embankment design parameters, foundation and abutment conditions, or static stability analyses to assess the seismic stability of this embankment were not available and therefore no inferences will be made regarding the seismic stability. An assessment of the seismic stability should be included as part of the stability analysis required by the guidelines.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. Several conditions observed during the recent inspection require monitoring and/or control:

(1) Erosion of material on the upstream embankment face and behind the left spillway retaining wall is occurring. If left unattended, this erosion will continue to deteriorate the embankment and could ultimately lead to failure.

(2) Evidence of seepage was observed near the right abutment.

(3) A stand of trees is located upstream of the spillway and obstructs flows through the spillway and sluice gate. The presence of this vegetation impairs the discharge efficiency of the spillway and sluice gate leading to increased overtopping potential.

(4) Although there is no noticeable recent movement of the cracked area of the upstream face, sloughing may be anticipated during high water levels in the reservoir.

(5) Continued deterioration of concrete at the downstream toe of the spillway may be detrimental to the stability of this appurtenance.

(6) The road crest is not graded adequately to provide for efficient drainage.

(7) Two small animal burrows were observed on the downstream face of the embankment.

Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

b. Adequacy of Information. Due to the lack of engineering design data, the conclusions in this report were based only on performance history and visual conditions. The inspection team considers that these data are sufficient to support the conclusions herein. However, seepage and stability analyses comparable to the guidelines were not available, which is considered a deficiency.

c. Urgency. It is the opinion of the inspection team that a program should be developed as soon as possible to implement remedial measures recommended in paragraph 7.2b. If the safety deficiencies listed in paragraph 7.1a are not corrected, they will continue to deteriorate and lead to a more serious potential of failure.

d. Necessity for Phase II. The Phase I investigation raises no serious questions relating to the safety of the dam nor does it identify any serious dangers that would require a Phase II investigation.

e. Seismic Stability. This dam is located in Seismic Zone 1. Adequate description of embankment design parameters, foundation and abutment conditions, or static stability analyses to assess the seismic stability of this embankment was not available and therefore no inferences will be made regarding the seismic stability. An assessment of the seismic stability should be included as part of the recommended stability analysis.

7.2 REMEDIAL MEASURES

a. Alternatives. The spillway has the capacity to pass 30 percent of the probable maximum flood without overtopping the dam. In order to pass 50 to 100 percent of the probable maximum flood as required by the Recommended Guidelines, the spillway size and/or height of dam would need to be increased.

b. Operation and Maintenance Procedures. The following operation and maintenance procedures are recommended and should be performed under the guidance of an experienced engineer in the design and construction of earth dams.

(1) Check the upstream and downstream face of the dam periodically for seepage and stability problems. If increased seepage flows, sloughing on the embankment slope, or enlargement of the observed crack are observed, the dam should immediately be inspected.

(2) A program should be developed for removal and control of trees and brush from the upstream embankment face and spillway approach.

(3) Erosion protection should be improved on the upstream slope and behind the left spillway retaining wall. This protection is needed to prevent erosion of the embankment material due to wave action and to spillway discharges.

(4) The roadway on the embankment crest should be graded to allow proper drainage of water from the crest.

(5) Measures should be implemented to maintain control of burrowing animals. Existing burrows should be repaired.

(6) The grass cover on the downstream slope should be mowed more frequently to allow observation of embankment conditions and to discourage burrowing animal activity.

(7) Appropriate repair measures should be taken to repair the deteriorated concrete at the downstream toe of the spillway.

(8) Seepage and stability analyses should be performed.

(9) A detailed inspection of the dam should be made periodically. More frequent inspections should be required if the noted deficiencies are not repaired or if additional deficiencies are observed.

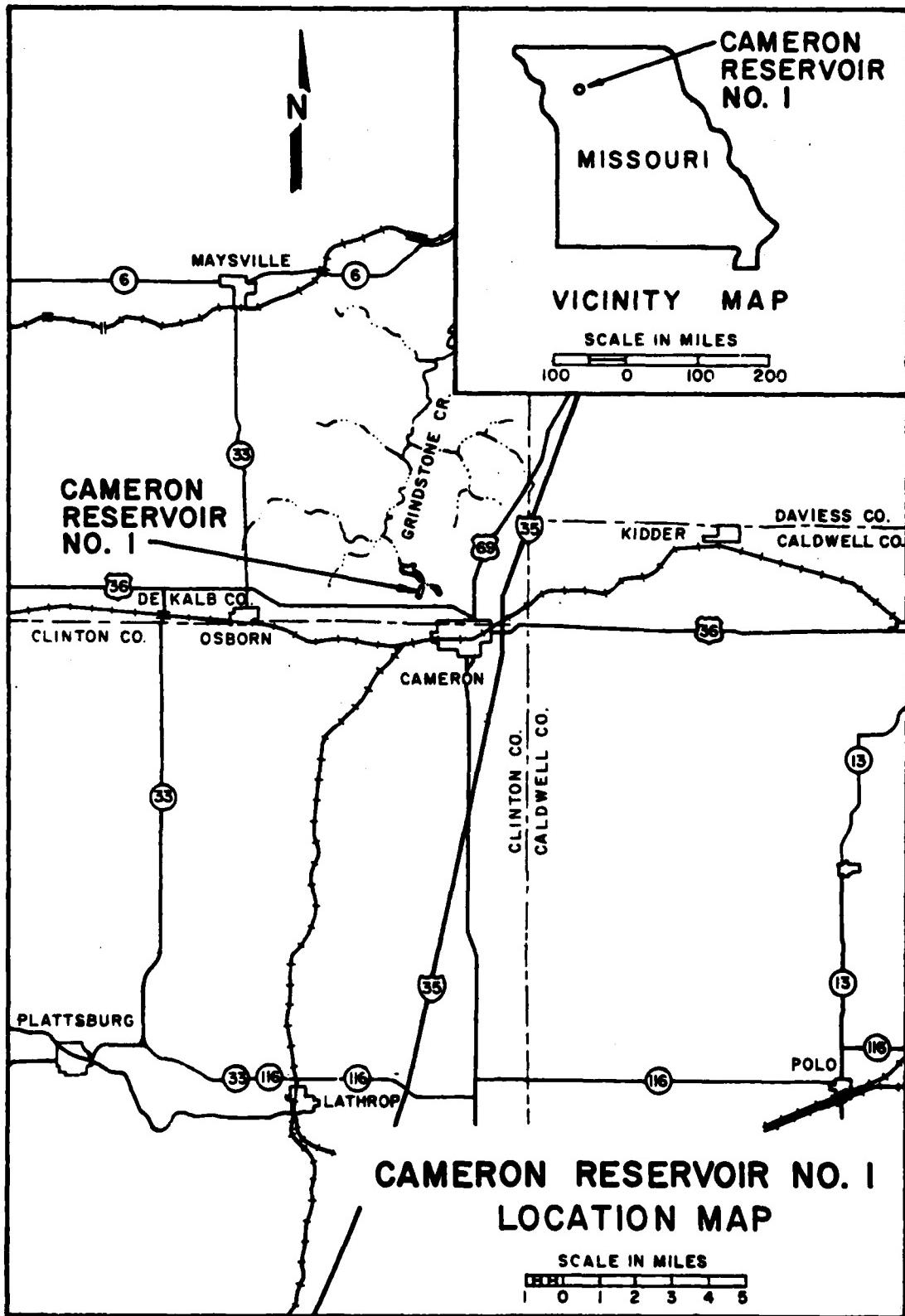
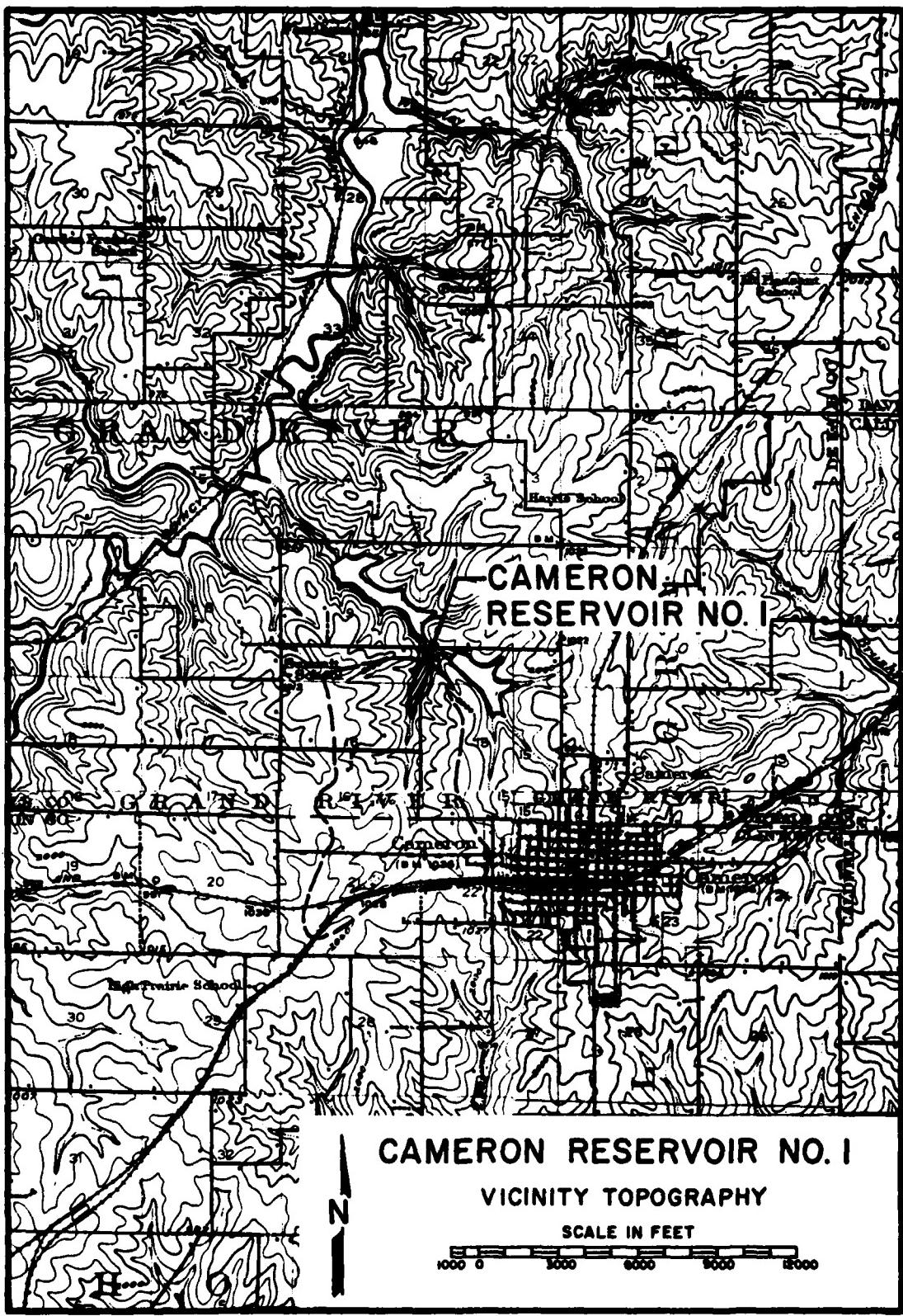
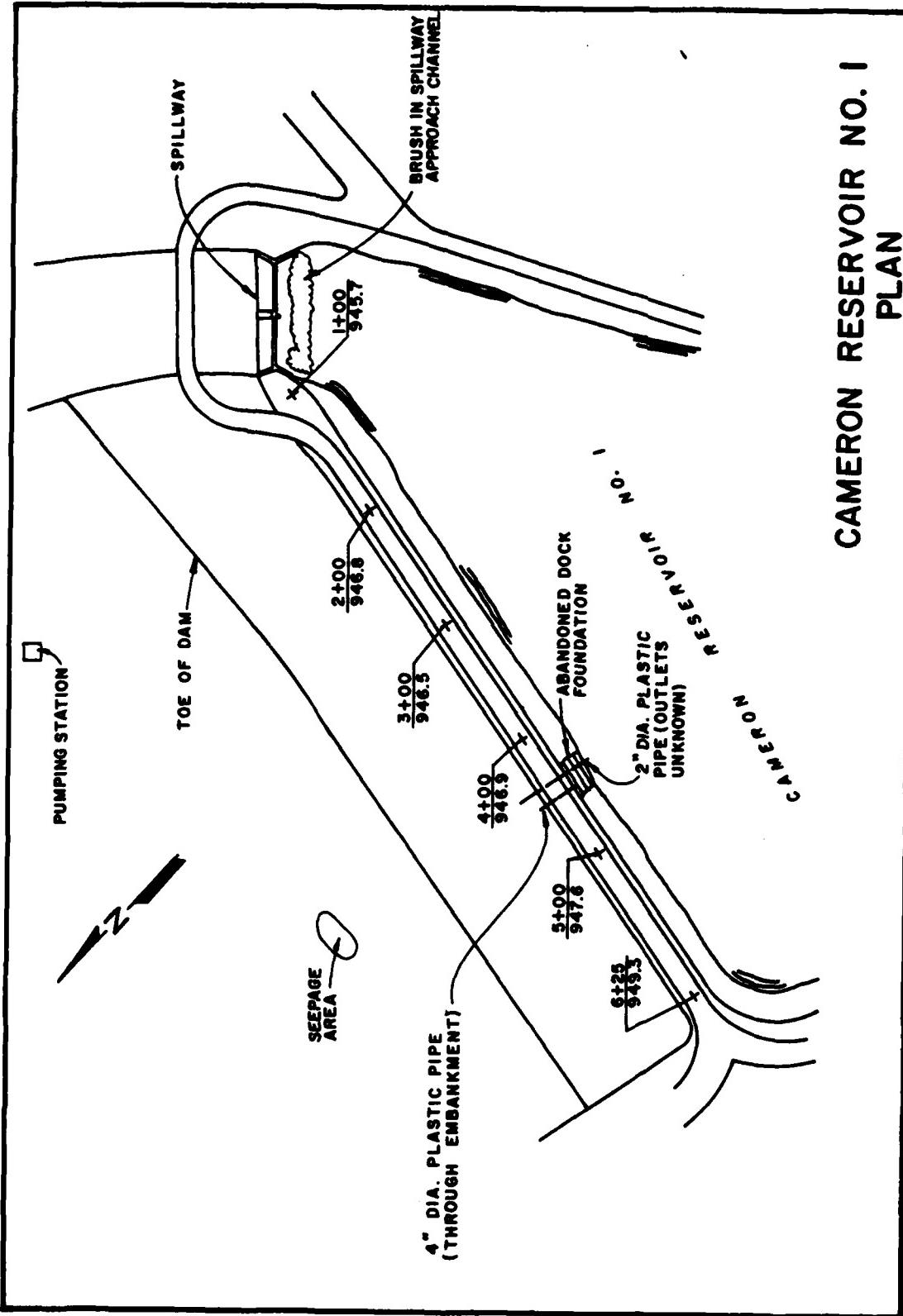


PLATE I



CAMERON RESERVOIR NO. I
PLAN

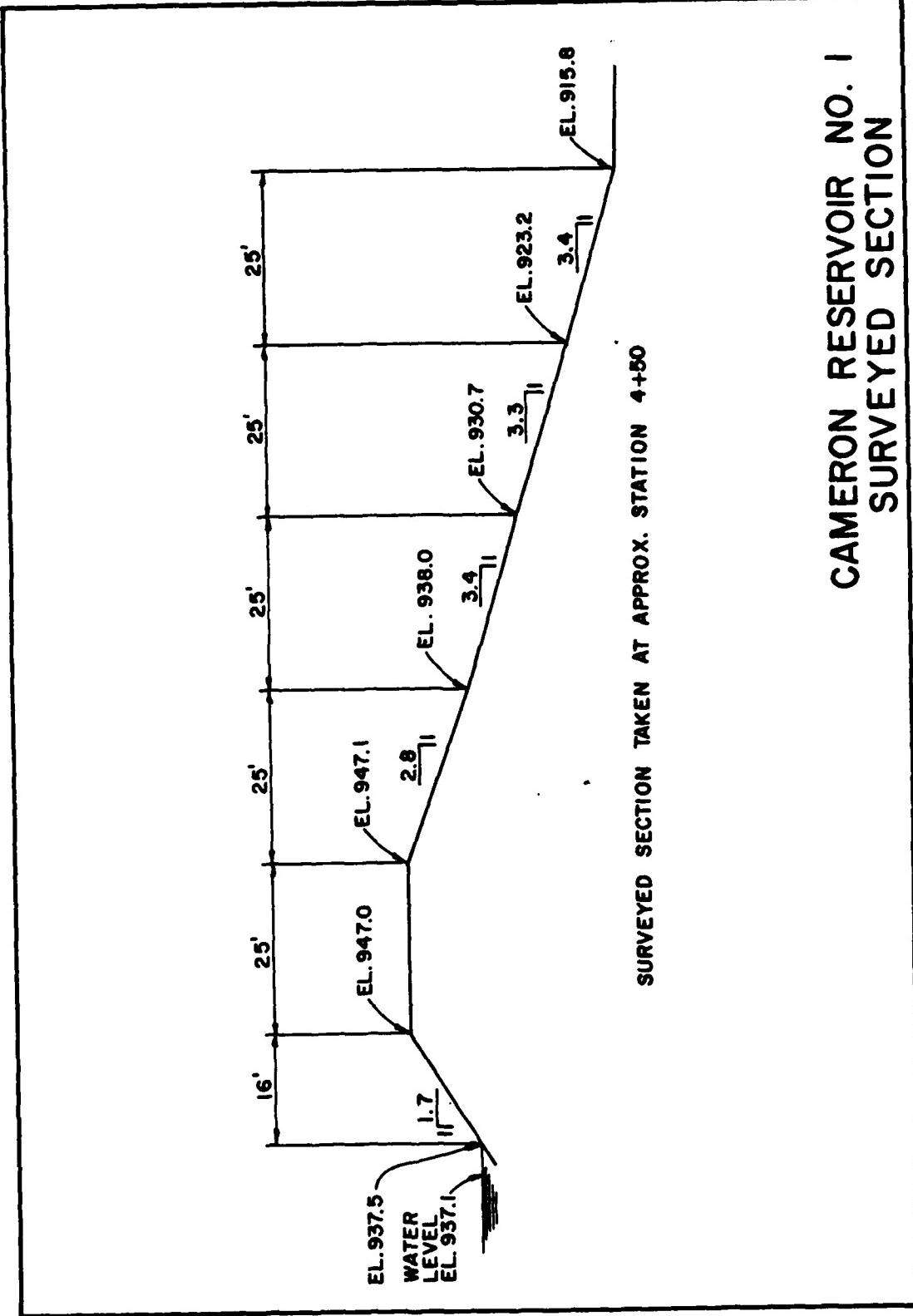
PLATE 3

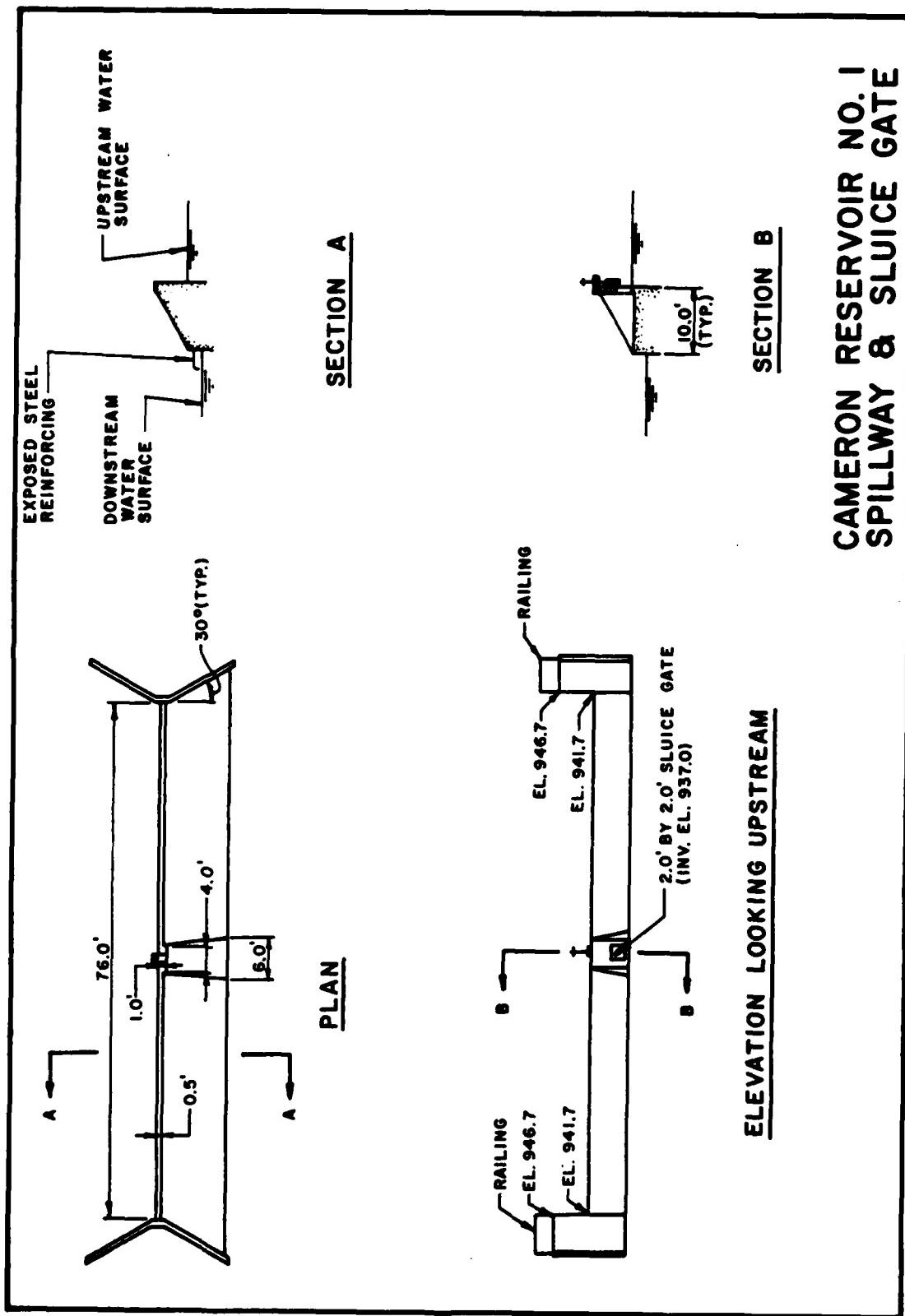


CAMERON RESERVOIR NO. I
SURVEYED SECTION

PLATE 4

SURVEYED SECTION TAKEN AT APPROX. STATION 4+50





CAMERON RESERVOIR NO. I
PHOTO INDEX

PLATE 6

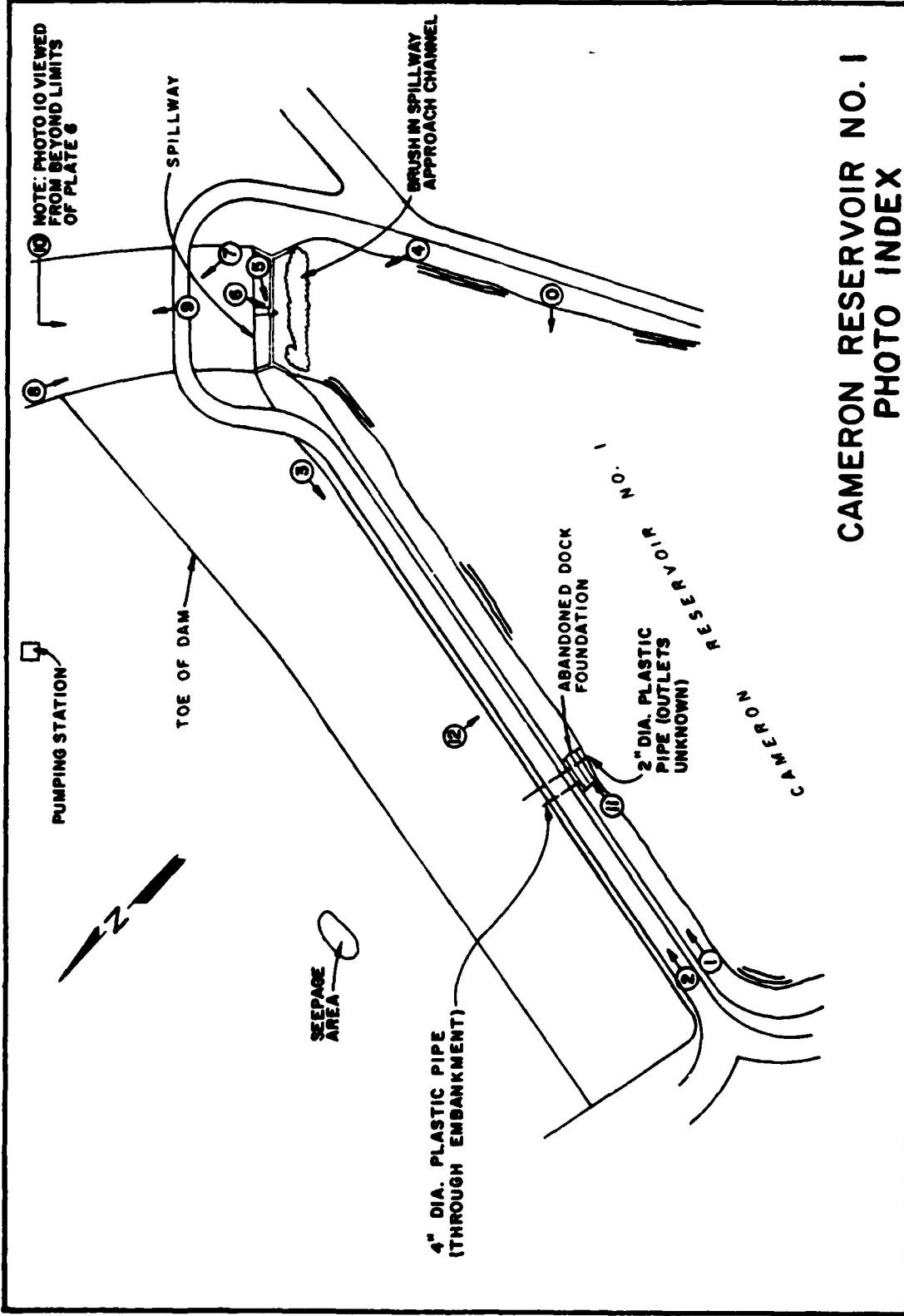




PHOTO 1: UPSTREAM FACE OF EMBANKMENT

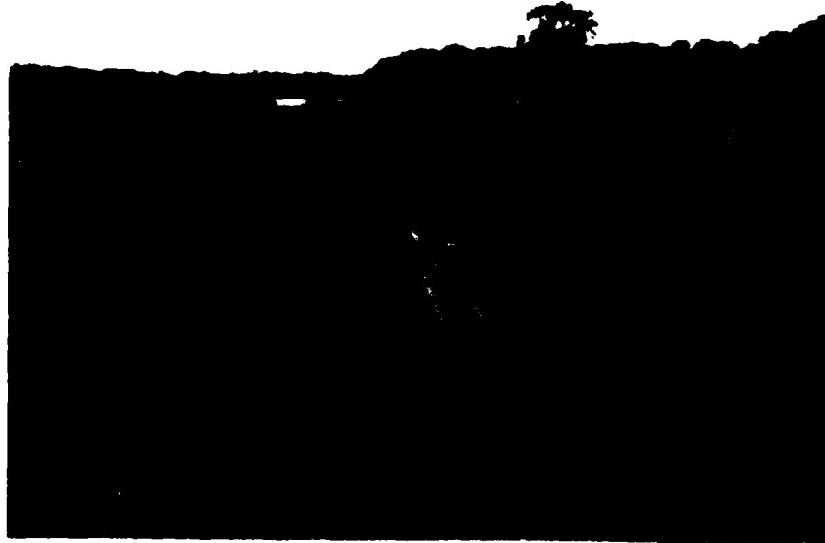


PHOTO 2: CREST OF EMBANKMENT

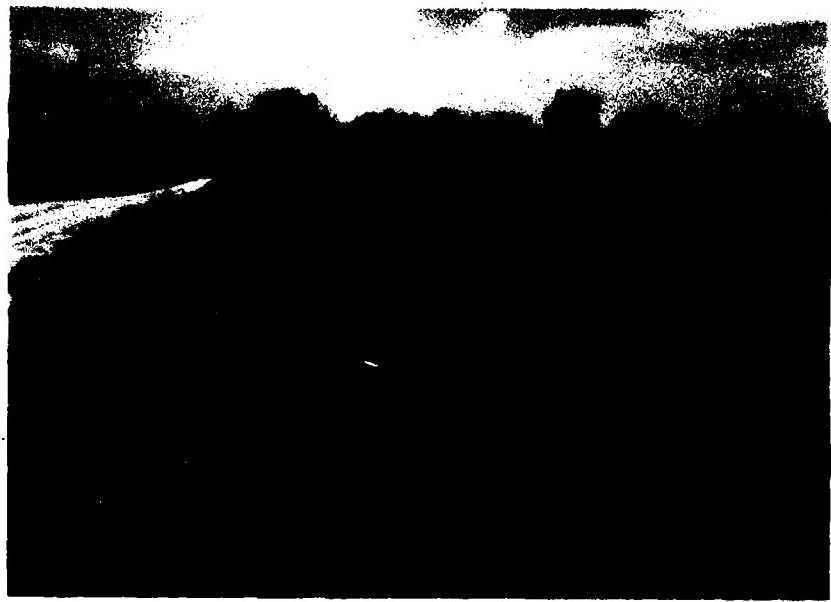


PHOTO 3: DOWNSTREAM FACE OF EMBANKMENT

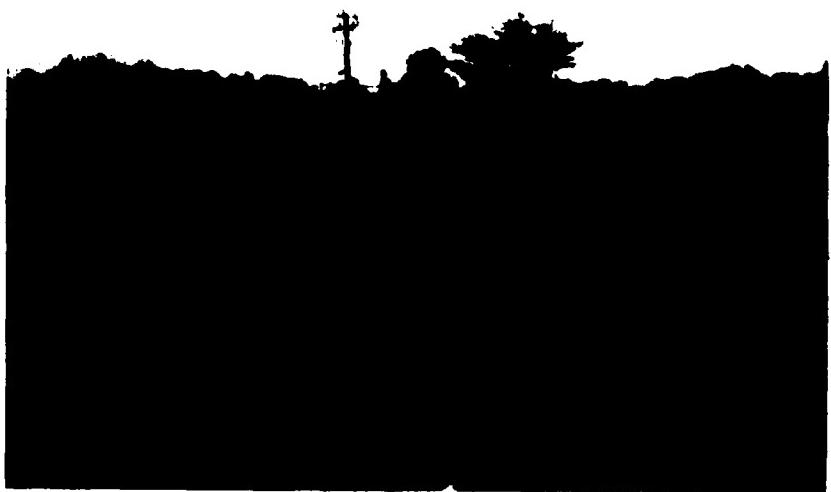


PHOTO 4: SPILLWAY APPROACH AND CREST (LOOKING DOWNSTREAM)



PHOTO 5: SPILLWAY CREST AND SLUICE GATE OPERATOR



PHOTO 6: SLUICE GATE DISCHARGE OUTLET



PHOTO 7: SPILLWAY DROP AND ROAD APPROXIMATELY 70 FEET
DOWNSTREAM OF SPILLWAY CREST



PHOTO 8: BENEATH SPILLWAY DROP AND ROAD (LOOKING UPSTREAM)



PHOTO 9: SPILLWAY DISCHARGE CHANNEL (LOOKING DOWNSTREAM FROM CREST OF SPILLWAY DROP AND ROAD)



PHOTO 10: SPILLWAY DISCHARGE CHANNEL (LOOKING UPSTREAM FROM POOL OF CAMERON RESERVOIR NO. 3)

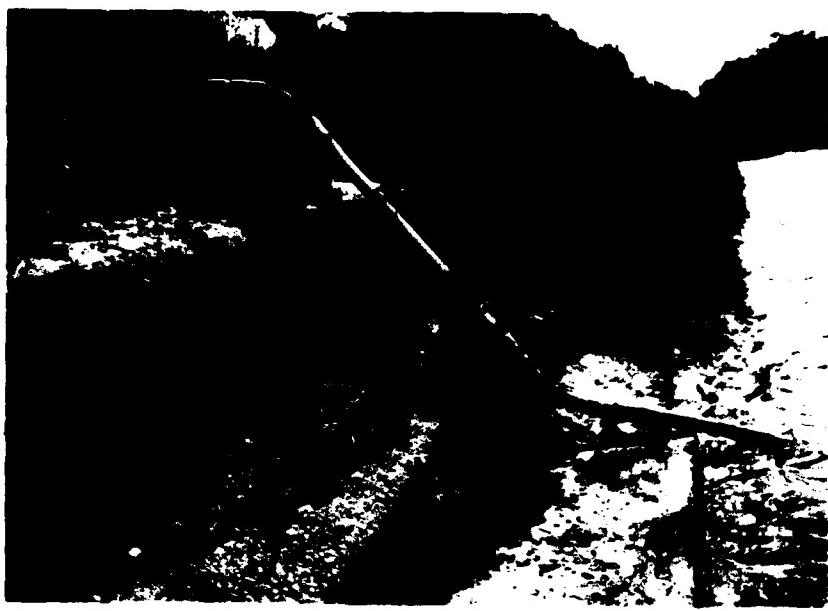


PHOTO 11: ABANDONED CONCRETE FOUNDATION AND PLASTIC PIPES
ON UPSTREAM FACE OF EMBANKMENT



PHOTO 12: ANIMAL BURROW ON DOWNSTREAM FACE OF EMBANKMENT

APPENDIX A
HYDROLOGIC COMPUTATIONS

HYDROLOGIC COMPUTATIONS

1. The Soil Conservation Service (SCS) dimensionless unit hydrograph and HEC-1 (1) were used to develop the inflow hydrographs, and hydrologic inputs are as follows:

a. Forty-eight hour, probable maximum precipitation determined from U.S. Weather Bureau Hydrometeorological Report No. 33.

200 square mile, 24 hour rainfall inches - 24.5

10 square mile, 6 hour percent of 24 hour
200 square mile rainfall - 101%

10 square mile, 12 hour percent of 24 hour
200 square mile rainfall - 120%

10 square mile, 24 hour percent of 24 hour
200 square mile rainfall - 130%

10 square mile, 48 hour percent of 24 hour
200 square mile rainfall - 140%

b. Drainage area = 1,174 acres.

c. Time of concentration:

$$T_c = (1.67) L$$

$$L = \frac{0.8 (S+1)^{0.7}}{1,900 Y^{0.5}}$$

L = lag in hours

= hydraulic length of watershed in feet

$$S = \frac{1,000}{CN'} - 10 \quad (\text{where } CN' \text{ is the retardance factor and is equivalent to the runoff curve number})$$

Y = average watershed land slope in percent

$$T_c = 1.94 \text{ hours (2).}$$

d. Losses were determined in accordance with SCS methods for determining runoff using a curve number of 94 and antecedent moisture condition III. The main soil associations in the watershed are Grundy, Lagonda, and Zook of the hydrologic soil group C. The land uses were

determined to be pasture, crops, and some urbanized area. The hydrologic condition was poor.

2. Discharge rates through the sluice gate are based on the weir and orifice flow equations, respectively:

Weir equation (for reservoir pool elevations between 937.0 and 939.0):

$$Q = CLH^{1.5} \quad (C = 2.5, L = 2.0 \text{ feet}, H \text{ is the head on weir}) \quad (3).$$

Orifice flow equation (for reservoir pool elevations above 939.0):

$$Q = Ca(2gh)^{0.5} \quad (C = 0.5, a = 4.0 \text{ sq ft}, g = 32.2 \text{ ft/sec}^2, h = \text{head on orifice in feet}) \quad (3).$$

Discharge rates over the spillway are based on the weir equation:

$$Q = CLH^{1.5} \quad (C \text{ varies from } 2.86 \text{ to } 3.32, L = 76 \text{ feet}).$$

Discharge rates over the top of the dam are based on the unlevel weir equation:

$$Q = \frac{2Cb}{5(h_b - h_a)} (h_b^{2.5} - h_a^{2.5})$$

(C = 2.63 = weir coefficient, b = the length of flow normal to the weir in feet, h_b = the head of the low end of the weir in feet, and h_a = the head on the high end of the weir in feet) (4).

3. The elevation-storage relationship above normal pool elevation was constructed by planimetrying the area enclosed within each contour above normal pool. The storage between two elevations was computed utilizing the conic method for computation of reservoir volume provided in HEC-1 (1). The summation of these increments below a given elevation is the storage below that level.

4. Routing of the 48-hour probable maximum flood through Cameron Reservoir No. 1 began with an initial elevation of 938.7, a surcharge of 1.7 feet on the sluice gate invert, due to the reservoir surface elevation not returning to the sluice gate invert resulting from applying a standard project flood in the preceding five days.

- (1) U.S. Army Corps of Engineers, Hydrologic Engineering Center, Flood Hydrograph Package (HEC-1), Dam Safety Version, July 1978, Davis, California.

- (2) U.S. Department of Agriculture, Soil Conservation Service, SCS National Engineering Handbook, Section 4, Hydrology, August, 1975.
- (3) Horace W. King and Ernest F. Brater, Handbook of Hydraulics, Sixth Edition, McGraw Hill Book Company, 1976.
- (4) U.S. Department of the Interior, Geological Survey, Techniques of Water-Resources Investigations, Book 3, Chapter A5, Measurement of Peak Discharge at Dams by Indirect Method, by Harry Hulsing, 1967.

MISSOURI BAN INSPECTION PROGRAM	
ARMED FORCES ENGINEERS	
U.S. ARMY CORPS OF ENGINEERS	
1	ASST. STATE ENGINEER
2	ASST. STATE ENGINEER
3	ASST. STATE ENGINEER
4	ASST. STATE ENGINEER
5	ASST. STATE ENGINEER
6	ASST. STATE ENGINEER
7	ASST. STATE ENGINEER
8	ASST. STATE ENGINEER
9	ASST. STATE ENGINEER
10	ASST. STATE ENGINEER
11	ASST. STATE ENGINEER
12	ASST. STATE ENGINEER
13	ASST. STATE ENGINEER
14	ASST. STATE ENGINEER
15	ASST. STATE ENGINEER
16	ASST. STATE ENGINEER
17	ASST. STATE ENGINEER
18	ASST. STATE ENGINEER
19	ASST. STATE ENGINEER
20	ASST. STATE ENGINEER
21	ASST. STATE ENGINEER
22	ASST. STATE ENGINEER
23	ASST. STATE ENGINEER
24	ASST. STATE ENGINEER
25	ASST. STATE ENGINEER
26	ASST. STATE ENGINEER
27	ASST. STATE ENGINEER

PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS
 RUNOFF HYDROGRAPH AT
 ROUTE HYDROGRAPH TO
 END OF NETWORK

	66	.07	.06	.00	521.	1.02	16.30	162	.87	.77	.00	7747.
1.01	16.30	.67	.06	.00	550.	1.02	16.45	163	.87	.87	.00	.04.
1.01	16.45	.67	.06	.00	579.	1.02	17.00	164	.87	.87	.00	.05.
1.01	17.00	.66	.06	.00	593.	1.02	17.15	165	.88	.88	.00	.05.
1.01	17.15	.69	.05	.00	649.	1.02	17.30	166	.88	.88	.00	.05.
1.01	17.30	.70	.05	.00	397.	1.02	17.45	167	.88	.88	.00	.05.
1.01	17.45	.71	.05	.00	358.	1.02	18.00	168	.88	.88	.00	.05.
1.01	17.60	.72	.05	.00	325.	1.02	18.15	169	.88	.88	.00	.05.
1.01	18.15	.73	.06	.00	103.	1.02	18.30	170	.88	.88	.00	.05.
1.01	18.30	.74	.06	.00	292.	1.02	18.45	171	.88	.88	.00	.05.
1.01	18.45	.75	.06	.00	253.	1.02	18.60	172	.88	.88	.00	.05.
1.01	18.60	.76	.06	.00	211.	1.02	19.00	172	.88	.88	.00	.05.
1.01	19.15	.77	.06	.00	170.	1.02	19.15	173	.88	.88	.00	.05.
1.01	19.30	.76	.06	.00	135.	1.02	19.30	174	.88	.88	.00	.05.
1.01	19.45	.79	.06	.00	103.	1.02	19.45	175	.88	.88	.00	.05.
1.01	20.00	.80	.06	.00	80.	1.02	20.00	176	.88	.88	.00	.05.
1.01	20.15	.81	.06	.00	64.	1.02	20.15	177	.88	.88	.00	.05.
1.01	20.30	.82	.06	.00	53.	1.02	20.30	178	.88	.88	.00	.05.
1.01	20.45	.83	.06	.00	43.	1.02	20.45	179	.88	.88	.00	.05.
1.01	20.60	.84	.06	.00	32.	1.02	20.60	180	.88	.88	.00	.05.
1.01	21.10	.85	.06	.00	23.	1.02	21.15	181	.88	.88	.00	.05.
1.01	21.45	.86	.06	.00	10.	1.02	21.30	182	.88	.88	.00	.05.
1.01	21.50	.86	.06	.00	27.	1.02	21.45	183	.88	.88	.00	.05.
1.01	21.65	.87	.06	.00	25.	1.02	22.00	184	.88	.88	.00	.05.
1.01	22.00	.88	.06	.00	25.	1.02	22.15	185	.88	.88	.00	.05.
1.01	22.15	.89	.06	.00	24.	1.02	22.30	186	.88	.88	.00	.05.
1.01	22.30	.90	.06	.00	23.	1.02	22.45	187	.88	.88	.00	.05.
1.01	22.45	.91	.06	.00	22.	1.02	23.00	188	.88	.88	.00	.05.
1.01	22.60	.92	.06	.00	22.	1.02	23.15	189	.88	.88	.00	.05.
1.01	22.75	.93	.06	.00	22.	1.02	23.30	190	.88	.88	.00	.05.
1.01	22.90	.94	.06	.00	21.	1.02	23.45	191	.88	.88	.00	.05.
1.01	23.05	.95	.06	.00	21.	1.02	23.60	192	.88	.88	.00	.05.
1.01	23.20	.96	.06	.00	21.	1.02	23.75	193	.88	.88	.00	.05.
1.02	0.00	.96	.06	.00	21.	1.03	0.00	192	.00	.00	.00	290.
							SUM	36.30	33.55	.75	156750.	
								1.87111452.14	1.192114438.673			

HYDROGRAPH AT STA 1 FOR PLAN 1, RATIO 1												
	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME		PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME	
CFS	8074.	4561.	1543.	82.	15660.		CFS	1615.	912.	309.	143.	51321.
CFS	239.	126.	44.	23.	443.		CFS	46.	26.	9.	5.	867.
INCHES		23.18	3.38	3.17	33.17		INCHES					6.63
INCHES		30.85	79.93	842.50	842.50		INCHES					6.63
MM		2261.	3061.	3216.	3216.		MM					6.63
AC-FT		226.	306.	324.	324.		AC-FT					6.63
THOUS CU M		3775.	3775.	3991.	3991.		THOUS CU M					6.63

HYDROGRAPH AT STA 1 FOR PLAN 1, RATIO 2												
	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME		PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME	
CFS	8074.	4561.	1543.	82.	15660.		CFS	1615.	912.	309.	143.	51321.
CFS	239.	126.	44.	23.	443.		CFS	46.	26.	9.	5.	867.
INCHES		23.18	3.38	3.17	33.17		INCHES					6.63
INCHES		30.85	79.93	842.50	842.50		INCHES					6.63
MM		2261.	3061.	3216.	3216.		MM					6.63
AC-FT		226.	306.	324.	324.		AC-FT					6.63
THOUS CU M		3775.	3775.	3991.	3991.		THOUS CU M					6.63

HYDROGRAPH AT STA 1 FOR PLAN 1, RATIO 3												
	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME		PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME	
CFS	8074.	4561.	1543.	82.	15660.		CFS	1615.	912.	309.	143.	51321.
CFS	239.	126.	44.	23.	443.		CFS	46.	26.	9.	5.	867.
INCHES		23.18	3.38	3.17	33.17		INCHES					6.63
INCHES		30.85	79.93	842.50	842.50		INCHES					6.63
MM		2261.	3061.	3216.	3216.		MM					6.63
AC-FT		226.	306.	324.	324.		AC-FT					6.63
THOUS CU M		3775.	3775.	3991.	3991.		THOUS CU M					6.63

P E A K S L O W A N D S T O R A G E (END OF PERIOD) SUMMARY OR MULTIPLE PIAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (Cubic meters per second)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO SLOPES					RATIO 6	RATIO 7	RATIO 8	RATIO 9
				RATIC 1	RATIC 2	RATIC 3	RATIO 4	RATIO 5				
HYDROGRAPH AT	1	1.83	1	207.	1615.	2019.	2622.	2826.	.3230.	.3635.	.6037.	.6074.
	1	4.763	1	22.663.	45.733.	37.163.	68.591.	80.021.	.91.461.	.102.891.	.114.321.	.228.641.
ROUTED TO	2	1.83	1	277.	1076.	1423.	1770.	2118.	.2544.	.2927.	.3296.	.7487.
	2	4.763	1	7.861.	20.661.	40.291.	50.111.	59.981.	.72.041.	.82.901.	.93.221.	.211.671.

SUMMARY OF DAM SAFETY ANALYSIS

PLAN NO. ELEVATION INITIAL VALUE SPILLWAY CREST TOP OF DAP
ELEVATION 938.70 937.00 935.70
SPILLAGE 100. 151. 650.
OUTFLOW 11. C. 2087.

RATIO OF RESERVOIR PPS TO ELEV.	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLO HOURS	TIME OF FAILURE HOURS
.10	942.50	0.00	418.	277.	0.00	43.00
.20	946.13	0.00	521.	106.	0.00	61.75
.25	944.73	0.00	562.	142.	0.00	61.75
.30	945.20	0.00	598.	170.	0.00	61.75
.35	945.73	0.00	632.	218.	0.50	61.50
.40	946.13	0.00	661.	254.	1.75	61.50
.45	946.43	0.00	687.	292.	2.25	61.50
.50	946.63	1.13	713.	329.	2.75	61.50
1.00	948.55	2.85	845.	7637.	5.50	61.00

FLOOD HYDROGRAPH PACKAGE (HEC-11)
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